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Technology Assessment Program

Emergency Vehicle Sirens

NIJ Standard-0501.00

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The Technology Assessment Program is sponsored by the Office of Development, Testing, and Dissemination of the National Institute of Justice (NIJ), U.S. Department of Justice. The program responds to the mandate of the Justice System Improvement Act of 1979, which created NIJ and directed it to encourage research and development to improve the criminal justice system and to disseminate the results to Federal, State, and local agencies.

The Technology Assessment Program is an applied research effort that determines the technological needs of justice system agencies, sets minimum performance standards for specific devices, tests commercially available equipment against those standards, and disseminates the standards and the test results to criminal justice agencies nationwide and internationally.

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Paul Cascarano, Assistant Director
National Institute of Justice

Technology Assessment Program

NIJ Standard for Emergency Vehicle Sirens

A Voluntary National Standard Promulgated by the National Institute of Justice.

December 1981

U.S. DEPARTMENT OF JUSTICE
National Institute of Justice

U.S. DEPARTMENT OF JUSTICE
National Institute of Justice

JAMES L. UNDERWOOD

Acting Director

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NIJ STANDARD
FOR
EMERGENCY VEHICLE SIRENS

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FOREWORD

This document, NIJ Standard-0501.00, Emergency Vehicle Sirens, is an equipment standard developed by the Law Enforcement Standards Laboratory of the National Bureau of Standards. It is produced as part of the Technology Assessment Program of the National Institute of Justice. A brief description of the program appears on the inside front cover.

This standard is a technical document that specifies performance and other requirements equipment must meet to conform to the needs of criminal justice agencies for high quality service. Purchasers can use the test methods described in this report to determine firsthand whether a particular piece of equipment meets the standards, or they may have the tests conducted on their behalf by a qualified testing laboratory. Procurement officials may also refer to this standard in their purchasing documents and require that equipment offered for purchase meet the requirements, with compliance guaranteed by the vendor or attested to by an independent laboratory.

Because this NIJ standard is designed as a procurement aid, it is necessarily highly technical. For those who seek general guidance about the capabilities of emergency vehicle sirens, user guides also are published. The guides explain in non-technical language how to select equipment capable of the performance required by an agency.

NIJ standards are subjected to continuing review. Technical comments and recommended revisions are welcome. Please send suggestions to the Program Manager for Standards, National Institute of Justice, U.S. Department of Justice, Washington, DC 20531.

Before citing this or any other NIJ standard in a contract document, users should verify that the most recent edition of the standard is used. Write to: Chief, Law Enforcement Standards Laboratory, National Bureau of Standards, Washington, DC 20234.

Lester D. Shubin
Program Manager for Standards
National Institute of Justice

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NIJ STANDARD FOR EMERGENCY VEHICLE SIRENS

1. PURPOSE AND SCOPE

The purpose of this document is to establish performance requirements and methods of test for electronic and electromechanical sirens used on law enforcement vehicles for the purpose of warning pedestrians and motorists of the passage of an emergency vehicle.

2. CLASSIFICATION

This standard establishes two classes of sirens, based upon acoustical output.

2.1 Class A

Sirens that provide as a minimum an A-weighted on-axis sound level of 120 dB and meet the off-axis sound level and other requirements of paragraph 4.3.

2.2 Class B

Sirens that provide as a minimum an A-weighted on-axis sound level of 115 dB and meet the off-axis sound level requirements of paragraph 4.3.

3. DEFINITIONS

3.1 Anechoic Room

A test room, the surfaces of which absorb at least 99% of the incident acoustic energy over the frequency range of interest.

3.2 Automatic Operation

The operational mode of a siren which produces a continuous cycling of sound level or tone (see Wail, Yelp and High-Low).

3.3 A-Weighted Sound Level

A quantity, in decibels (dB) read from a sound level meter or other acoustical instrumentation system that fulfills the requirements of American National Standard S1.4-1971—Type 1 [1]* that is switched to its weighting network labeled "A." The A-weighting network discriminates against the lower sound frequencies according to a relationship approximating the auditory sensitivity of the human ear at moderate sound levels.

3.4 Sound Pressure Level (Lp)

A quantity, in decibels (dB) read from a sound level meter or other acoustical measurement instrumentation system that fulfills the requirements of American National Standard S1.4-1971—Type [1] that is switched to the "flat" or unweighted network. The sound pressure level (Lp) is defined by $Lp = 20 \log_{10} (p/p_o)$, where p is the sound

*Numbers in brackets refer to references in appendix A.

pressure and p_o is the reference pressure. For the purposes of this standard, the value of p_o used in this standard is 20 μPa ($20 \times 10^{-6} N/m^2$). Unless otherwise explicitly stated the sound pressure is the effective (rms) sound pressure.

3.5 Manual Operation

The manual operational mode of a siren that produces a rising frequency (pitch) until either the apex is reached or the control is released. The operator can produce a wailing sound in this mode of operation by alternately closing and releasing a momentary contact switch.

3.6 High-Low

The operational mode of a siren that produces a pattern of alternating high and low tones at a nominal cycling rate of 40 to 60 c/m (cycles per minute).

3.7 Wail

The operational mode of a siren that produces a tonal pattern of slow, automatic increases and decreases in frequency at a nominal cycling rate that ranges from 15 to 30 c/m.

3.8 Yelp

The operational mode of a siren that produces a tonal pattern of rapid, automatic increases and decreases in frequency at a nominal cycling rate of 160 to 240 c/m.

4. REQUIREMENTS

4.1 General

4.1.1 Markings

(a) The input power requirements shall be permanently inscribed on the siren or on a nameplate affixed thereto. The letters and numerals shall be at least 3.0 mm (1/8 in) in height.

(b) The siren or speaker housing shall be clearly marked to indicate, when installed, the proper orientation of the siren or speaker with respect to the longitudinal centerline and the front of the vehicle.

(c) The controls for all functions shall be clearly and appropriately identified on the housing or box upon which the controls are located. Manual foot or horn controls distal from the housing or box need not be marked.

(d) The classification of the siren in accordance with section 2 shall be permanently marked on the siren manufacturer's nameplate in letters at least 5.0 mm (3/16 in) in height.

(e) The siren or speaker shall be clearly labeled to identify acceptable mounting locations; i.e., roof/external mounting or under hood installation.

4.1.2 Certification

The manufacturer shall certify that the siren meets the requirements of this standard for the classification that has been assigned.

4.1.3 Manufacturer Provided Information

The manufacturer shall provide complete warranty information and instructions and precautions, if any, concerning the installation, operation and routine maintenance of the siren. Such instructions shall include, but not be limited to:

a) Specification for the installation of multiple speakers of an electronic siren system on the vehicle. These shall include the distance between speakers, the angle between the orientation marking of each speaker and the longitudinal centerline of the vehicle, and the orientation (e.g., horizontal or vertical) of the long axis of the speaker opening, if it is other than circular.

b) A warning, in the case of an electronic siren, similar to the following:

"If speakers for electronic sirens are mounted in multiple configurations other than that specified by the manufacturer or distributor, partial cancellation of the acoustical signals developed by each speaker may result so that reduced sound levels may occur in some directions."

4.1.4 Design and Safety

The siren control unit shall be designed to reduce its potential for causing injuries during normal operations and in accident situations. An inspection of the siren shall reveal no burrs or sharp edges. An adequate electrical insulation and grounding shall be provided as required by SAE Recommended Practice J556, Automobile Wiring [5].

4.1.5 Electrical

The siren system covered by this standard shall operate on a standard nominal 12 V dc automobile electrical system with negative ground. When tested in accordance with paragraph 5.4, the power drain (wattage) of the siren shall not exceed that specified by the manufacturer (par. 4.1.1.a) at 13.6 V dc and the operating power (wattage) of electronic sirens shall not exceed the rating of the speaker coil at the test voltage of 13.6 V dc and shall not exceed 105% of the wattage ratings of the speaker coils when measured at 15.0 V dc.

4.2 Operating Life

When tested in accordance with paragraph 5.5, an electromechanical siren shall operate at full rated output in the manual mode in a sequence of 5 min on and 1 min off for 30 min without failure caused by overheating; and an electronic siren shall operate at full rated output in the manual mode in a sequence of 5 min on and 1 min off for 60 min without failure.

4.3 Acoustical Performance

When tested in accordance with paragraph 5.6, class A and B sirens shall provide minimum on-axis A-weighted sound levels of 120 and 115 dB; respectively for all modes of operation (high-low, yelp, and wail, as appropriate) and the A-weighted sound levels of the yelp mode at off-axis positions of ±10, 20, 30, 40, and 50° shall equal or exceed the values specified in table 1. It shall be permissible for any three of the measured sound levels for an individual siren at any axial position to fall below the values specified in table 1 by an amount not to exceed 1.0 dB, provided that the sound levels of at least three of the remaining eight axial measurement positions exceed the values specified in table 1 by 1.0 dB or more.

When measured in accordance with paragraph 5.4, the maximum octave-band sound level measured on-axis shall occur in either the 1000 or 2000 Hz octave bands.

TABLE 1. *Siren classification*

	Minimum acceptable acoustical performance A-weighted sound level (dB)					
	0°	±10°	±20°	±30°	±40°	±50°
Class A	120	119	118	117	115	113
Class B	115	114	113	112	110	108

4.4 Environmental Performance

Following environmental testing in accordance with paragraphs 5.7.1 through 5.7.6, the A-weighted sound level of class A and class B sirens for any operating mode when measured on-axis in accordance with paragraphs 5.8, shall not be reduced by an amount greater than 5.0 dB.

In addition, there shall be no evidence of intermittent operation of the siren, no evidence of excessive corrosion inside the siren, speaker or horn, and no loosened, cracked or worn wiring or parts.

5. TEST METHODS

5.1 General

The inspection and test procedures contained in this section are to be used to determine the conformance of products to the requirements of this standard. Each producer or distributor who represents his products as conforming to this standard may utilize statistically based sampling plans which are appropriate for each particular manufacturing process, but shall keep such essential records as are necessary to document his claim that all of the requirements of this standard have been met. Additional sampling and testing of the product, as may be agreed upon between purchaser and seller, is not precluded by this section.

The acoustic spectrum of a siren varies with time in a complex manner, and it is important that the sound level measurement procedures presented in this section are followed without deviation. The critical nature of the sound level measurement is discussed in appendix B.

5.2 Testing Procedures

5.2.1 Test Sequence

The tests shall be conducted in the order presented in the paragraphs that follow.

5.2.2 Test Conditions

Unless otherwise specified in this standard, all tests shall be conducted at ambient atmospheric pressure (approximately 29–31 in of mercury, or 98 to 105 kPa) and room temperature (approximately 65° to 80 °F, or 18° to 27 °C), and at the relative humidity prevailing at the test site.

5.2.3 Test Facility

The test facility shall be an anechoic room with wall treatment that absorbs no less than 99% of the incident acoustic energy generated in the range of 500 Hz to 20 kHz. The anechoic room shall meet the requirements for optimal (measurement) condition indoors in section 3.4.3 of American National Standard Methods for the Measurement of Sound Pressure Levels S1.13-1971 [3]. Unless otherwise specified, the procedures for selection of instrumentation, installation and operation of the siren, and measurement of the siren sound output shall be as indicated in sections 5, 6, and 8.4 of that standard.

5.2.4 Test Equipment

The following equipment is suggested to facilitate testing:

a. A lightweight test base approximately 30×30×2.5 cm (12×12×1 in) for mounting the siren or speakers. The support for the siren horn or projector shall be capable of being rotated from 0° to ±50° and shall position the axis of the siren or horn(s) or projector(s) at a height of at least 1.5 m (5.0 ft) above the major surface of the support. The axial positions shall be determined to an accuracy of ±0.5°. With the exception of a mounting platform of dimensions no greater than 30×30×2.5 cm (12×12×1 in) to which the horn(s) or projector(s) is (are) mounted, the test stand shall contain no reflecting surfaces with dimensions greater than 2.5 cm (1.0 in) within 1.5 m (5.0 ft) of the horn(s) or projector(s).

b. The power supply or supplies in use shall be adjustable to provide a voltage at the siren input terminals of 13.6 V or 15.0 V dc as required for the specific test.

c. The sound level meter or other acoustical measurement instrumentation system shall meet the requirements of ANSI S1.4-1971—Type 1 [1]; and

d. The octave band filter sets shall meet class II requirements of American National Standard, Specification for Octave, One-Half Octave and One-Third Octave Band Filter Sets S1.11-1966 (R1971) [2].

e. The wattmeter shall have a frequency range from dc to 1600 Hz, field ratings of 10 A and 62.5 V, a scale range of 250 W and 1% accuracy.

5.2.5 Test Voltage

Unless otherwise stated, the test voltage shall be 13.6 V dc, as obtained at the input terminals of an electronic siren or an electromechanical siren. The 12 V automotive battery, if used for testing, shall have a mimimum cranking rate at -18 °C (0 °F) of

450 A for 30 s and a reserve capacity of 100 min, rated at a level of 25 A. The battery shall be at full power at the start of the tests and maintained at full power by the use of a battery charger throughout the duration of the tests. A stable, well-regulated power supply (±0.25 V dc, maximum ripple 75 mV peak to peak, output current equal to 1.5 times the rated current for the siren under test) may be used in lieu of an automotive battery.

5.2.6 Test Records

A complete record of all tests will be prepared by the testing facility and maintained for future reference by interested parties.

5.3 Inspection

Inspect the siren and any information supplied with the siren by the manufacturer to determine compliance with the requirements of paragraphs 4.1.1 through 4.1.5, inclusive.

5.4 Wattage Test

5.4.1 Set-up

Place the siren under test on a test stand in an anechoic chamber. Connect the wattmeter (par. 5.2.4.e) to the input terminals of an electromechanical siren, and to the speaker or driver coils of an electronic siren. Connect the power terminals of the siren under test to a power supply that meets the requirements of paragraph 5.2.5.

During the tests which follow, and any subsequent testing during which the sirens are operating, technicians and observers shall remain outside of the anechoic chamber, and shall use attenuating hearing protectors during initial set-up and any adjustments.

5.4.2 Wattage Measurement

Activate the siren under test at an input voltage of 13.6 V with the siren in the manual mode of operation. After the siren has operated for a period of 3 min, note and record the power drain (wattage). Repeat this test with the siren operating in the wail, high-low, and yelp modes, as appropriate.

Increase the input voltage to the siren to 15 V dc and repeat the procedure as above, except that the siren shall operate for a period of 10 min prior to measuring the power drain.

5.5 Operating Life

Without changing the test set-up as described in paragraph 5.2, adjust the input voltage to 13.6 V. Turn the siren on in the manual mode of operation and test the siren as follows:

a. Operate an electromechanical siren for a period of 30 min, cycling the siren on 5 min and off 1 min, noting any failure induced by overheating.

b. Operate an electronic siren for a period of 60 min cycling the siren on 5 min and off 1 min, noting any failure induced by overheating.

5.6 Acoustical Performance

Place the siren under test on the support table (par. 5.2.4.a) in an anechoic chamber meeting the requirements of paragraph 5.2.3 at a height of 1.5 m (5.0 ft) above the major support surface. Position the microphone as shown in figure 1. The measuring microphone shall be mounted at a distance of 3.0 m (9.8 ft) from the edge of the siren horn or projector, in line with the siren axis and at the same height as the siren axis. The microphone shall be mounted at normal incidence to the siren axis. The siren shall be located as far from the walls of the anechoic chamber as practicable. There shall be no significant reflecting surfaces within 1.5 m (5.0 ft) of the microphone used for measurement of the generated signal or within 1.5 m (5.0 ft) of the path between the siren or speaker and the microphone.

Connect the microphone to a measurement instrumentation system that meets the requirements of paragraphs 5.2.4.c and 5.2.4.d and position the siren so that the acoustical axis is aligned with that of the microphone (0° position). Connect the siren to the power supply and adjust the input voltage to 13.6 V dc.

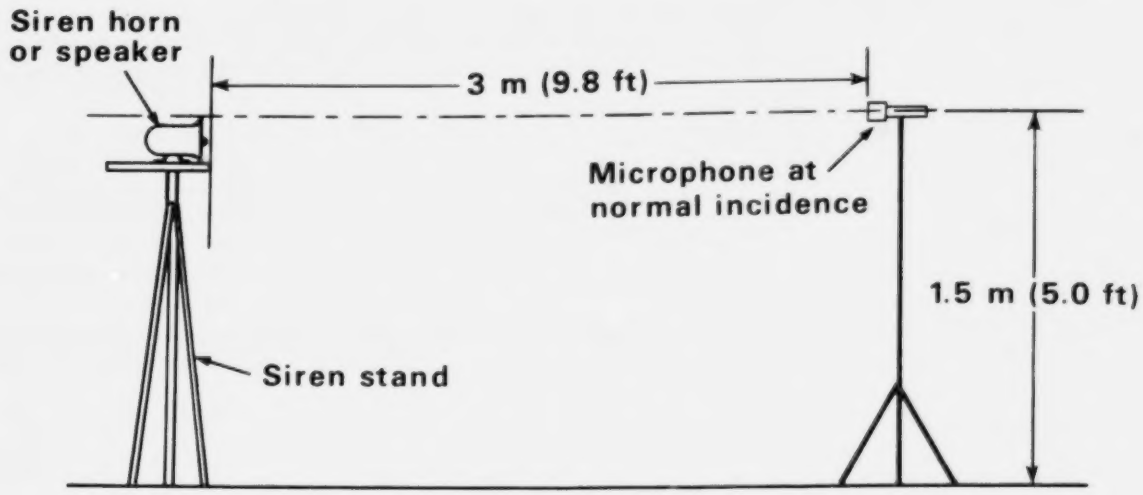

FIGURE 1. Typical test setup inside anechoic room.

Use the measurement instrumentation to measure the sound level in the octave band centered at 1000 Hz. This typically requires switching from the "A-weighted" to the "external filter" setting. Turn the siren on in the manual mode of operation and after a period of 1 min, measure and record the sound pressure level. Repeat this test using the 500 Hz, 2000 Hz, and 4000 Hz filter settings, rather than the 1000 Hz filter.

Without changing the test set-up, adjust the measuring instrumentation to measure the A-weighted sound level. Adjust the response characteristics of the measurement instrumentation to provide a time constant of 30 s.

Turn the siren on in the yelp mode, wait 1 min, measure the A-weighted sound level, and record the measured value. Manually adjust the position of the siren to an off-axis position of either $\pm 10°$ and repeat the measurement of the sound level in the yelp mode. Manually adjust the position of the siren until sound level measurements have been made at 10° intervals to 50° on each side of the 0° position. Then, return the siren to the 0° position and once more measure the sound level of the siren in the yelp mode after 1 min of operation.

With the siren still positioned on-axis, measure the sound pressure level after 1 min of operation in each of the remaining modes of operation: manual, wail, high-low. Record the data.

Original test data are to be obtained and recorded to the nearest 0.2 dB. However, for the purposes of comparison with the limits specified in section 4.3 of this standard, all of these sound level data shall be rounded to the nearest integer decibel; e.g., an on-axis sound level of 114.5 dB is acceptable for Class B performance, provided that other requirements are met.

The data shall be recorded in tabular form as follows:

A-Weighted Sound Level (dB) at 3 m

0°	+10°	+20°	+30°	+40°	+50°
0°	−10°	−20°	−30°	−40°	−50°

The average value of the two on-axis sound level measurements shall be used for classification purposes. This average shall be obtained from the unrounded original data, and then rounded to integer decibel values, to avoid cumulative round-off error.

During the conduct of these tests, technicians and observers shall remain outside the anechoic chamber. During the test period, the air temperature and humidity shall be measured and the calibration of the measuring system shall be verified using a pistonphone or calibrator at intervals not to exceed 1 h. The test conditions shall be reported with the sound level measurements including a record of complete calibration of the measurement system prior to and upon completion of the testing of

each siren. Any changes in sensitivity during the calibration shall be noted and the test shall be regarded as invalid for changes in 1 dB or greater.

5.7 Environmental Tests

No acoustical measurements are required during exposure of the siren under test to the environmental tests that follow. However, while the siren is in the environmental state specified in paragraphs 5.7.1 and 5.7.2, and at the completion of the tests specified in paragraphs 5.7.3 through 5.7.5, power shall be applied to the siren and each function operated continuously for a period of 5 min. During these periods of operation the wattage of the siren shall be measured in the last minute of operation. Any indication of apparently abnormal operation during these tests shall be noted on the test record and brought to the attention of the individuals responsible for the post environment acoustical tests.

5.7.1 High Temperature Test

(a) Roof Mounted Sirens

Mount the entire siren assembly, including those parts which are normally mounted inside the passenger space of the vehicle, in accordance with the manufacturer's instructions for electrical hookup, within an environmental chamber. Raise the chamber temperature to 71 °C (160 °F) ±2 °C (3.6 °F) for a period of 4 h.

(b) Sirens Mounted Under the Hood

Those parts of the siren assembly normally mounted under the hood or behind the grille, i.e., the electronic siren speaker(s) or electromechanical siren assembly, shall be tested in accordance with section 5.7.1(a), except that the test chamber temperature shall be 90 °C (195 °F) ±2 °C (3.6 °F) for a period of 4 h.

5.7.2 Low Temperature Test

Mount the entire siren assembly, including those parts that are normally mounted inside the passenger space of the vehicle, in accordance with the manufacturer's instructions for electrical hookup, within an environmental chamber. Lower the chamber temperature to −40 °C (−40 °F) ±2 °C (3.6 °F) for a period of 4 h.

5.7.3 Dust Test

Mount the siren assembly which is normally mounted external to the passenger space of the emergency vehicle, with all drain holes open, in its normal operating orientation at least 0.15 m (6 in) from the wall in a cubical box with inside measurements of 0.9 m (3 ft) on each side. Place 4.5 kg (10 lbs) of fine powdered cement as specified in ASTM C150-77, "Specification for Portland Cement" [4], with the exception of type 3, in the box. At intervals of 15 min, agitate this dust by compressed air or by a fan blower by projecting blasts of air for a period of 2 s in a downward direction into the dust in such a way that the dust is completely and uniformly diffused throughout the entire cube. Continue this test for 5 h. Clean the exterior surface.

5.7.4 Moisture Test

Mount the parts of the siren assembly that are normally mounted external to the passenger space of the emergency vehicle in their operating orientation with all drain holes open. Subject the parts to a precipitation of 0.25 cm (0.1 in) of water per minute, delivered in a cone spray at an angle of 45° from the horizontal. The horn of the siren shall be positioned normal to the vertical axis of the spray cone. Continue the test for 12 h. Following the test, drain the siren under room ambient conditions for a period of 1 h.

5.7.5 Corrosion Resistance Test

Mount the parts of the siren assembly, which are normally mounted external to the passenger space of the emergency vehicle, in a fog chamber in their normal operating orientation, with all drain holes open. Generate fog by atomizing a salt solution through a nozzle or nozzles. The salt solution shall be prepared by dissolving 5±1% parts by weight of salt in 95 parts of distilled water or water containing not more than 200 p/m of total solids. The salt used shall be sodium chloride, substantially free of nickel and copper, and containing on the dry basis not more than 0.1%

of sodium iodide and not more than 0.2% of total impurities. The pH of the salt solution shall be such that when atomized at 35 °C (95 °F) the collected solution will be in the pH range of 6.5 to 7.2. Before the solution is atomized it shall be free of suspended solids. The compressed air supply to the nozzle or nozzles for atomizing the salt solution shall be free of oil and dirt and maintained at 69 to 172 kPa (10 to 25 lbs/in^2). The nozzle or nozzles shall be so directed or baffled that none of the spray impinges directly on the siren assembly. The fog shall be such that for each 80 cm^2 (12.40 in^2) of horizontal collecting area there shall be collected from 1.0 to 2.0 cm^3 (0.06 to 0.12 in^3) of solution per hour. Expose the siren to the spray for 50 h.

5.7.6 Vibration Test

The electromechanical siren, electronic siren speaker, and electronic siren amplifier(s) shall be vibration tested separately. Each component shall be affixed to a metal plate using the mounting supplied by the manufacturer or distributor for a normal installation. Bolt the plate to the anvil end of the table of a vibration test machine which meets the requirements of SAE Standard J575g, "Tests for Motor Vehicle Lighting Devices" [6]. Subject the components to vibration in the vertical plane during one complete sweep cycle, with a constant peak to peak amplitude of 1.0±0.1 mm (0.039±0.004 in) varying the frequency from 10 to 55 Hz and return to 10 Hz at a linear sweep rate of 2 min/complete sweep cycle.

5.8 Post Environmental Test

Following the environmental testing described in paragraph 5.7, the siren shall be inspected for any evidence of excessive corrosion inside the siren horn or speaker, loosened, cracked or worn wiring or parts. The siren shall then be operated for 5 min in each operational mode.

Without making any adjustments to the siren, return it to the acoustical chamber and repeat the on-axis measurements only as described in paragraph 5.6. Compare the post environmental test acoustic performance data with the pre-environmental acoustic data, to determine compliance with the requirements of paragraph 4.4.

APPENDIX A—REFERENCES

1. American National Standard Specification for Sound Level Meters, S1.4-1971 (American National Standards Institute, New York, NY, April 1971).
2. American National Standard Specifications for Octave, Half Octave, and Third Octave Band Filter Sets, S1.11-1966 (R1971). (American National Standards Institute, New York, NY, 1971).
3. American National Standard Methods for the Measurement of Sound Pressure Level, S1.13-1971 (American National Standards Institute, New York, NY, July 1971).
4. American Society for Testing and Materials Specification for Portland Cement, ASTM C150-77, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA.
5. Society of Automotive Engineers Recommended Practice J556, Automotive Wiring, Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.
6. Society of Automotive Engineers Standard Tests for Motor Vehicle Lighting Devices and Components, SAE J575g Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

APPENDIX B—MEASUREMENTS OF EMERGENCY VEHICLE SIREN ACOUSTICAL OUTPUT

Emergency vehicle warning sirens normally provide several modes of operation:

- The manual mode of operation allows the operator to activate the siren, which allows it to increase to its maximum steady state frequency acoustical output.
- The wail mode produces a tonal pattern of slow, automatic increases and decreases in frequency at a nominal cycling rate that ranges from 15 to 30 c/m.
- The high-low mode produces a pattern of automatic alternating high and low tones at a nominal cycling rate of 40 to 60 c/m.
- The yelp mode produces a tonal pattern of rapid automatic increases and decreases in frequency at a nominal cycling rate of 160 to 240 c/m.

The acoustical energy produced by a siren is at the maximum level in the forward direction, radiating from the siren in all directions. An evaluation of the acoustical performance of a siren requires a measure of the sound level both on-axis (the forward direction) and to either side of the forward axis to establish off-axis sound levels for that portion of the signal that fans out into intersections, particularly in urban areas. Since the radial distribution of the siren signal is of interest in the range 50° to either side of the on-axis signal, there is a tendency to record the acoustic spectrum as a function of axial position using an automatic traverse with a turntable that rotates the siren with a constant angular velocity. The rate of angular rotation afforded by conventional turntables is such that sound level measurements made using such a system are at best ambiguous. This is a consequence of the fact that the acoustical energy of the siren varies in a cyclic manner at a cycle rate between 15 and 240 c/m depending upon the mode of operation and when combined with the turntable rotation rate of approximately 0.1 rad/s, it is difficult to accurately determine either the peak sound level or average sound pressure level at given axial position. The measurements are also greatly influenced by the integration time of the sound measurement system that is used for such tests.

The polar representation of a siren output is complicated in general by inadequate control of the rotation rate of the turntable and/or incompatibility of the cycle time of the operating mode of the siren and/or uncertain averaging times associated with the sound level recording device, therefore the test methods used in this standard require that the siren be stationary during the measurement, and that the axial position be established by manual positioning. In order to insure reproducible test results, the procedures establish the A-weighted long-term rms sound level as the basis for compliance with the requirements of this standard.

Because of the complicated variation with time for the sound output from sirens, the procedures suggested for the measurement of nonsteady noise in section 8.4.2 of American National Standard S1.13-1971 are appropriate. The principal source of difficulty in performing an accurate and precise measurement of the sound level is related to the relative averaging time of the sound level meter and the cycle time for each operating mode of the siren. More accurate and precise measurements are obtained when the averaging time of the meter substantially exceeds the cycle time. For this reason, the use of an averaging time sufficient to reduce meter fluctuations to a minimum, is required in this standard. The classification procedure of this standard is based upon preferred use of a 30 s averaging time and the yelp mode.

The frequency spectrum of the signal that is used to drive the speaker, or horn, of an electronic siren is essentially the same, regardless of the mode of operation. As a result, the sound level as a function of location with respect to the on-axis sound level is determined by the speaker characteristics. The relative sound level at any location, then, is independent of the mode of operation of the siren, as long as the driver is not saturated with power or over-driven. This has been verified by laboratory tests. Consequently, it is only necessary to measure the sound level at the off-axis positions for a single mode of operation. Since operation in the yelp mode permits the most precise determination of the A-weighted sound level of the siren, that mode of operation was selected for off-axis measurements in the standard.

For measurements of the sound level output of the wail and high-low mode, every effort shall be taken to estimate the level corresponding to true (long-term) rms sound pressure when the averaging time corresponds to at least several cycles of the siren operating mode. A preferred method for this process requires the use of measurement instrumentation with an averaging time constant of 30 s. An alternative procedure requires observation of the fluctuations of the indicating device on the noise measurement instrumentation when set to the "slow" characteristic. If the fluctuations in the indication device are less than ±3 dB, the level corresponding to the true long-term rms

sound pressure may be estimated from the arithmetic means of the maximum and minimum values observed. If the fluctuations are between ± 3 dB and ± 5 dB, the level corresponding to the true rms sound pressure may be estimated as approximately 3 dB below the maximum level observed. See sections 8.4.2.1 and 8.4.2.2 of American National Standard Methods for the Measurement of Sound Pressure levels S1.13-1971.

* United States Government Printing Office:1981--361-233/6343

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